

What is claimed is:

CLAIMS:

1. A process for determining polymer product properties in a slurry reactor system, the process comprising:
 - (a) obtaining a regression model for determining a polymer product property, the regression model including principal component loadings and principal component scores;
 - (b) acquiring a Raman spectrum of the polymer product in the slurry reactor system;
 - (c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings; and
 - (d) calculating the polymer product property by applying the new principal component score to the regression model.
2. The process of claim 1, wherein the step of obtaining a regression model comprises:
 - (i) obtaining a plurality of Raman spectra of the polymer product;
 - (ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and
 - (iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polymer property to the principal component scores.
3. The process of claim 1, wherein the regression model is a locally weighted regression model.
4. The process of claim 1, wherein the polymer product property is selected from density, melt flow rate, molecular weight, molecular weight distribution, tab swell, and functions thereof.

5. The process of claim 1, wherein the polymer product comprises polyolefin particles.
6. The process of claim 1, wherein the step of acquiring a Raman spectrum comprises:
 - (i) providing a Raman probe in optical communication with the polymer product in the slurry reactor system; and
 - (ii) irradiating the polymer product and collecting scattered radiation using the Raman probe.
7. The process of claim 1, wherein the slurry reactor system is a slurry loop reactor system.
8. The process of claim 1, wherein the slurry reactor system is a stirred slurry reactor system.
9. The process of claim 1, further comprising:
 - (i) obtaining a second regression model for determining a second property of the polymer product, the second regression model including second principal component loadings and second principal component scores;
 - (ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and
 - (iii) calculating the second property of the polymer product by applying the new second principal component score to the second regression model.
10. The process of claim 9, wherein the two properties of the polymer product are a melt flow rate and density.
11. The process of claim 9, further comprising:

- (i) obtaining a third regression model for determining a third property of the polymer product, the third regression model including third principal component loadings and third principal component scores;
 - (ii) calculating a new third principal component score from at least a portion of the Raman spectrum and the third principal component loadings; and
 - (iii) calculating the third property of the polymer product by applying the new third principal component score to the third regression model.
- 12. The process of claim 11, wherein the three properties of the polymer product are a melt flow rate, density, and tab swell.
- 13. A process for determining polyolefin product properties in a slurry loop reactor system, the process comprising:
 - (a) obtaining a locally weighted regression model for determining a polyolefin product property selected from density, melt flow rate, molecular weight, molecular weight distribution, tab swell, and functions thereof, the locally weighted regression model including principal component loadings and principal component scores;
 - (b) acquiring a Raman spectrum of a the polyolefin product in the slurry loop reactor;
 - (c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings; and
 - (d) calculating the polyolefin product property by applying the new principal component score to the locally weighted regression model.
- 14. The process of claim 13, wherein the step of obtaining a regression model comprises:
 - (i) obtaining a plurality of Raman spectra of the polyolefin product;

- (ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and
 - (iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polyolefin product property to the principal component scores.
- 15. The process of claim 13, wherein the step of acquiring a Raman spectrum comprises:
 - (i) providing a Raman probe in optical communication with the polyolefin product in the slurry reactor system; and
 - (ii) irradiating the sample and collecting scattered radiation using the Raman probe.
- 16. The process of claim 13, further comprising:
 - (i) obtaining a second regression model for determining a second property of the polyolefin product, the second regression model including second principal component loadings and second principal component scores;
 - (ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and
 - (iii) calculating the second property of the polyolefin product by applying the new second principal component score to the second regression model.
- 17. The process of claim 16, wherein the two properties of the polyolefin product are a melt flow rate and density.
- 18. The process of claim 16, further comprising:
 - (i) obtaining a third regression model for determining a third property of the polyolefin product, the third regression model including third

- principal component loadings and third principal component scores;
- (ii) calculating a new third principal component score from at least a portion of the Raman spectrum and the third principal component loadings; and
 - (iii) calculating the third property of the polyolefin product by applying the new third principal component score to the third regression model.
19. The process of claim 18, wherein the three properties of the polyolefin product are a melt flow rate, density, and tab swell.
20. A process for controlling polymer properties in a slurry reactor system, the process comprising:
- (a) obtaining a regression model for determining a polymer product property, the regression model including principal component loadings and principal component scores;
 - (b) acquiring a Raman spectrum of the polymer product in the slurry reactor system;
 - (c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings;
 - (d) calculating the polymer product property by applying the new principal component score to the regression model; and
 - (e) adjusting at least one polymerization parameter based on the calculated polymer product property.
21. The process of claim 20, wherein the step of obtaining a regression model comprises:
- (i) obtaining a plurality of Raman spectra of the polymer product;
 - (ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and

- (iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polymer product property to the principal component scores.
- 22. The process of claim 20, wherein the regression model is a locally weighted regression model.
- 23. The process of claim 20, wherein the polymer product property is selected from density, melt flow rate, molecular weight, molecular weight distribution, tab swell, and functions thereof.
- 24. The process of claim 20, wherein the polymer product comprises polyolefin particles.
- 25. The process of claim 24, wherein the step of acquiring a Raman spectrum comprises:
 - (i) providing a Raman probe in optical communication with the polymer product in the slurry reactor system; and
 - (ii) irradiating the polymer product and collecting scattered radiation using the Raman probe.
- 26. The process of claim 20, wherein the slurry reactor system is a slurry loop reactor system.
- 27. The process of claim 20, wherein the slurry reactor system is a stirred slurry reactor system.
- 28. The process of claim 20, wherein the at least one polymerization parameter is selected from the group consisting of monomer feed rate, comonomer feed rate, catalyst feed rate, hydrogen gas feed rate, slurry density, and reaction temperature.

29. The process of claim 20, further comprising:
- (i) obtaining a second regression model for determining a second property of the polymer product, the second regression model including second principal component loadings and second principal component scores;
 - (ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and
 - (iii) calculating the second property of the polymer product by applying the new second principal component score to the second regression model,
- and wherein the step of adjusting comprises adjusting at least one polymerization parameter based on the calculated property of the polymer product, the calculated second property of the polymer product, or both calculated polymer product properties.
30. The process of claim 29, wherein the two properties of the polymer product are a melt flow rate and density.
31. The process of claim 29, further comprising:
- (i) obtaining a third regression model for determining a third property of the polymer product, the third regression model including third principal component loadings and third principal component scores;
 - (ii) calculating a new third principal component score from at least a portion of the Raman spectrum and the third principal component loadings; and
 - (iii) calculating the third property of the polymer product by applying the new third principal component score to the third regression model,
- and wherein the step of adjusting comprises adjusting at least one polymerization parameter based on the calculated property of the polymer

product, the calculated second property of the polymer product, the calculated third property of the polymer product, or a combination thereof.

32. The process of claim 31, wherein the three properties of the polymer product are a melt flow rate, density, and tab swell.
33. A process for controlling polyolefin product properties in a slurry loop reactor system, the process comprising:
 - (a) obtaining a locally weighted regression model for determining a polyolefin product property selected from density, melt flow rate, molecular weight, molecular weight distribution, tab swell, and functions thereof, the locally weighted regression model including principal component loadings and principal component scores;
 - (b) acquiring a Raman spectrum of the polyolefin product in the slurry loop reactor system;
 - (c) calculating a new principal component score from at least a portion of the Raman spectrum and the principal component loadings;
 - (d) calculating the polyolefin product property by applying the new principal component score to the locally weighted regression model; and
 - (e) adjusting at least one polymerization parameter based on the calculated polyolefin product property.
34. The process of claim 33, wherein the step of obtaining a regression model comprises:
 - (i) obtaining a plurality of Raman spectra of the polyolefin product;
 - (ii) calculating principal component loadings and principal component scores from the spectra obtained in (i) using principal component analysis (PCA); and
 - (iii) forming the regression model using the principal component scores calculated in (ii) such that the regression model correlates the polyolefin product property to the principal component scores.

35. The process of claim 33, wherein the step of acquiring a Raman spectrum comprises:
- (i) providing a Raman probe in optical communication with the polyolefin polymer product in the slurry loop reactor system; and
 - (ii) irradiating the sample and collecting scattered radiation using the Raman probe.
36. The process of claim 33, wherein the at least one polymerization parameter is selected from the group consisting of monomer feed rate, comonomer feed rate, catalyst feed rate, hydrogen gas feed rate, slurry density, and reaction temperature.
37. The process of claim 33, further comprising:
- (i) obtaining a second regression model for determining a second property of the polyolefin product, the second regression model including second principal component loadings and second principal component scores;
 - (ii) calculating a new second principal component score from at least a portion of the Raman spectrum and the second principal component loadings; and
 - (iii) calculating the second property of the polyolefin product by applying the new second principal component score to the second regression model,
- and wherein the step of adjusting comprises adjusting at least one polymerization parameter based on the calculated property of the polyolefin product, the calculated second property of the polyolefin product, or both calculated polyolefin product properties.
38. The process of claim 37, wherein the two properties of the polyolefin product are a melt flow rate and density.

39. The process of claim 37, further comprising:
- (i) obtaining a third regression model for determining a third property of the polyolefin product, the third regression model including third principal component loadings and third principal component scores;
 - (ii) calculating a new third principal component score from at least a portion of the Raman spectrum and the third principal component loadings; and
 - (iii) calculating the third property of the polyolefin product by applying the new third principal component score to the third regression model,
- and wherein the step of adjusting comprises adjusting at least one polymerization parameter based on the calculated property of the polyolefin product, the calculated second property of the polyolefin product, the calculated third property of the polyolefin product, or a combination thereof.
40. The process of claim 30, wherein the three properties of the polyolefin product are a melt flow rate, density, and tab swell.